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Space Effects Survivability Testing

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**Abstract**

A versatile space environments test facility has been designed and built to study the effects on small satellites and system components. Testing for potentially environment-induced modifications of small satellites is critical to avoid possible deleterious or catastrophic effects over the duration of space missions. This is increasingly more important as small satellite programs have longer mission lifetimes, expand to more harsh environments (such as solar or geosynchronous orbits), and in some cases, must withstand longer duration stress tests due to new technology research. This test facility simulates critical environmental components including the neutral gas atmosphere, the vacuum environment, solar flux, solar plasma fluxes, and temperature. The UV/Vis/NIR solar spectrum is simulated using an external class AAA Solar Simulator source, with standard Air Mass Zero (AM0) filters to shape the incident radiation spectrum. A second medium-amplitude (~20 keV to ~100 keV) low-flux electron source utilizes filament-free photoemission. A 5m raditation source produces a high-energy spectrum similar to the geosynchronous environment, intensities of ~3x the geosynchronous spectrum are possible.

**Space Environment Characteristics**

The Space Survivability chamber simulates several critical characteristics of the space environment: electron flux, photon flux, temperature, and neutral gas environment. An electron flux simulator shows representative electron spectra for several common environments: the ran of the chambers, two electron guns, and Sr source are shown. The solar UV/Vis/NIR spectrum is shown in Figure 10: source includes a standard solar simulator (~200 to 2000 nm) and Kr resonance source to mimic the L Hyman spectrum at 121.6 nm. Samples are in a low density particle environment, using an evacuated neutral gas test environment down to ~10^-11 Pa. Temperature can be maintained for prolonged testing from ~100 K to ~450 K. This chamber does not yet simulate ions, plasma or atomic oxygen.

**Experimental Test Chamber Design**

Versatile ultrahigh vacuum test chamber provides controlled temperature and vacuum environment with stable, uniform, long-duration electron and UV/Vis/NIR fluxes up to at least 4 times the equivalent intensities for accelerated testing for a sensitivity area of 6 cm x 6 cm. Particularly well suited for cost-effective tests of multiple small scale materials samples over prolonged exposure.

**Space Simulation Capabilities**

- **Electron Flux:** Electron flood guns (A) provide ≤10^6 electrons/cm² (1 pA·cm²) flux needed to simulate the solar wind at more than 100x cumulative electron flux. Monoenergetic energy range is ~3 x 10^6 to 10^-10 keV. Gun provides a ~5% uniform flux distribution over the full sample area, with "hot swap" filament heads for continuous exposure over the entire long duration testing. The electron guns use custom designed (LEI after work by) Swainmathan (2004)
- **Infrared/Visible/UV light simulator:** A commercial AAA solar simulator (B) provides NIR/UV/Vis electromagnetic radiation from 350 to 1700 nm at 4 times equivalent intensity for accelerated testing over an area of 600mm x 600mm. Source uses a Xe discharge tube, parabolic reflector, collimating lens, and standard Air Mass Zero filters to match the inner radiation spectrum of the solar atmosphere. Xe bulbs have ~3 month lifetimes for long duration studies.
- **Far Ultraviolet:** The Kr resonance lamps (C) provide FUV radiation ranging from 10 to 200 nm at 4 times equivalent intensity. Three lamps oriented 120° apart provide a flux uniformity. Lamp’s emission lines reproduce the H Lyman-alpha line (121.6 nm) that dominates the solar FUV spectrum. Kr bulbs have ~3 month lifetimes for long duration studies.
- **Flux Mask:** Flux mask (E) located near the chamber’s top ports restricts the flux boundaries to the sample stage, limiting equipment exposure and reducing scattering to accommodate uniform exposure. Can be readily modified for different sample geometries.
- **Vacuum Chamber:** Uses standard mechanical and turbomolecular pumps (P) for roughing and an ion pump (I) for continuous maintenance-free operation (base pressure < 1x10^-11 Pa).
- **Temperature:** A temperature range from 100 K to 450 K is maintained using a standard PID temperature controller, using a cryogenic reservoir (Q) and resistance heaters (R) attached to a large thermal mass sample stage (S).